

What Is Claimed Is:

1. An apparatus for determining the orientation of a medical device within a patient's body, comprising:

5 a catheter having a tube wall defining a lumen therethrough; and
 a plurality of tube wall bending indicators located at least on or within the catheter wall at a reference portion of the catheter to become curved where the catheter passes through an anatomical reference when the distal end of the catheter is at a target site within the patient's body;

10 wherein the plurality of tube wall bending indicators provide an indication of tube wall bending to indicate the orientation of the reference portion of the catheter relative to the anatomical reference.

2. The apparatus of claim 1, wherein the catheter further comprises:

15 a distal outlet in communication with the lumen, and the orientation of the catheter distal outlet relative to the anatomical reference is to be determined based on a predetermined orientation of the catheter distal outlet relative to the reference portion of the catheter and the orientation of the reference portion of the catheter relative to the anatomical reference.

20 3. The apparatus of claim 1 wherein the tube wall bending indicators comprise:

 a plurality of strain gages for providing said indication of tube wall bending by changing an electrical resistance in accordance with an amount of tube wall bending within the vicinity of each strain gage.

25 4. The apparatus of claim 3, further comprising an orientation display to display an indication of the orientation of the reference portion of the catheter relative to the anatomical reference based on the electrical resistance change of the strain gages.

5. The apparatus of claim 1, wherein the tube wall bending indicators comprise:

30 a plurality of rods movably embedded in the catheter wall, wherein each of the rods extends from a proximal end of the catheter to at least the reference portion of the catheter that

becomes curved when the catheter is placed at the target site, the rods to provide said indication of tube wall bending by changing an amount of protrusion relative to the proximal end of the catheter in accordance with an amount of tube wall bending in the vicinity of each rod.

5 6. A method of using a catheter comprising:
 placing a distal end of a catheter at a target site within a patient's body; and
 determining the orientation of the distal end of the catheter relative to the target site based
on an indication from tube wall bending indicators of localized tube wall bending around a
known anatomical reference.

10 7. The method of claim 6 wherein said determining the orientation of the distal end of
the catheter relative to the target site comprises:
 determining the orientation of the catheter relative to the target site based on a change in
tensile stress in the tube wall bending indicators.

15 8. The method of claim 6 wherein said determining the orientation of the distal end of
the catheter relative to the target site comprises:
 determining the orientation of the catheter relative to the target site based on a change in
compressive stress in the tube wall bending indicators.

20 9. The method of claim 6 wherein said determining the orientation of the distal end of
the catheter relative to the target site comprises:
 determining the orientation of the catheter relative to the target site based on a change in
tensile stress and compressive stress in the tube wall bending indicators.

25 10. The method of claim 6 wherein said determining the orientation of the distal end of
the catheter relative to the target site comprises:
 determining the orientation of the catheter relative to the target site based on a change in
tensile strain in the tube wall bending indicators.

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11. The method of claim 6 wherein said determining the orientation of the distal end of the catheter relative to the target site comprises:

determining the orientation of the catheter relative to the target site based on a change in compressive strain in the tube wall bending indicators.

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12. The method of claim 6 wherein said determining the orientation of the distal end of the catheter relative to the target site comprises:

determining the orientation of the catheter relative to the target site based on a change in tensile strain and compressive strain in the tube wall bending indicators.

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13. A system for determining the orientation of a medical device within a patient's body, comprising:

a catheter having a tube wall defining a lumen therethrough and a distal outlet proximate to a distal end of the catheter in communication with the lumen;

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a plurality of tube wall bending indicators located at least on or within the tube wall at a reference portion of the catheter to become curved where the catheter passes through an anatomical reference when the distal end of the catheter is proximate to a target site within the patient's body, the plurality of tube wall bending indicators to provide an indication of the orientation of the reference portion of the catheter relative to the anatomical reference; and

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an imaging device to image the catheter distal end, the imaging device to provide an indication of a position of the catheter distal end relative to the target site;

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said orientation of the distal outlet relative to the target site to be determined based on the indicated orientation of the reference portion of the catheter relative to the anatomical reference as indicated by the tube wall bending indicators and the position of the catheter distal end as indicated by the imaging device.

14. The system of claim 13, wherein the imaging device comprises a fluoroscopic device.

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15. The system of claim 13, wherein the tube wall bending indicators comprise:
a plurality of strain gages to provide said indication of tube wall bending by changing an electrical resistance in accordance with an amount of tube wall bending within the vicinity of each strain gage.

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16. The system of claim 15, further comprising:
an orientation display to display an indication of the orientation of the reference portion of the catheter relative to the anatomical reference based on the electrical resistance change of the strain gages.

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17. The system of claim 13, wherein the tube wall bending indicators comprise:
a plurality of rods movably embedded in the catheter wall, wherein each of the rods extends from a proximal end of the catheter to at least the reference portion of the catheter that becomes curved when the catheter is placed at the target site, the plurality of rods to provide said indication of tube wall bending by changing an amount of protrusion relative to the proximal end of the catheter in accordance with an amount of tube wall bending in the vicinity of each rod.

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18. A method for determining the orientation of a medical device within a patient's body, comprising:

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placing a distal end of a catheter at a target site within the patient's body, the catheter including a tube wall defining a lumen therethrough, a distal outlet in communication with the lumen, and a plurality of tube wall bending indicators located at least on or within the tube wall at a reference portion of the catheter to become curved where the catheter passes through an anatomical reference when the distal end of the catheter is at the target site;

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determining the orientation of the reference portion of the catheter relative to the anatomical reference based on an indication of tube wall bending provided by the plurality of tube wall bending indicators;

determining the position of the catheter distal end relative to the target site by imaging of the distal end of the catheter with an imaging device; and

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determining the orientation of the catheter outlet relative to the target site based on the orientation of the reference portion of the catheter relative to the anatomical reference as

indicated by the tube wall bending indicators and the position of the catheter distal end as indicated by the imaging device.

19. The method of claim 18, wherein determining the orientation of the reference portion
5 of the catheter relative to the anatomical reference further comprises:

identifying one of the plurality of bending indicators indicating the highest tensile stress or strain in the catheter wall as the bending indicator closest to an outside radius of the catheter in the curved portion of the catheter within the anatomical reference; and

determining the orientation of the reference portion of the catheter relative to the
10 anatomical reference based on the orientation of the bending indicator corresponding to the highest tensile stress or strain in the tube wall.

20. The method of claim 18, wherein the tube wall bending indicators comprise:

strain gages for providing said indication of tube wall bending by changing an electrical
15 resistance in accordance with an amount of tube wall bending within the vicinity of each strain gage.

21. The method of claim 18, wherein the tube wall bending indicators comprise:

a plurality of rods movably embedded in the catheter wall, wherein each of the rods
20 extends from a proximal end of the catheter to at least the reference portion of the catheter that becomes curved when the catheter is placed at the target site, the rods for providing said indication of tube wall bending by changing an amount of protrusion relative to the proximal end of the catheter in accordance with an amount of tube wall bending in the vicinity of each rod.